Visual Comparison of Diagonal Structures: More Evidence for Spatial Alignment

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Abstract. Comparing diagrammatic representations is an effective way to grasp underlying spatial relationships, and the placement of diagrams can affect the efficiency of comparison. Recently, Matlen, Gentner, and Franconeri (2020) proposed the *spatial alignment hypothesis* – that visual comparison is optimized when visuals are placed perpendicular to their main structural axes. In their study, comparison was most efficient for visuals in direct placement (e.g., visuals with horizontal axes placed vertically) relative to impeded placement (e.g., horizontal axes placed horizontally), and vice versa for visuals with vertical axes. However, still untested is whether spatial alignment applies *beyond* horizontal or vertical spatial structures. We explore this question using diagonally structured visuals, and find that the predictions of spatial alignment bear out: participants are faster and more accurate for direct relative to impeded alignments, suggesting that spatial alignment is a broadly relevant principle for visual comparison. We discuss our results in relation to design and instruction.

Keywords: Visual Comparison, Spatial Alignment, Analogy.

1 Introduction

Diagrammatic representations are useful for displaying spatial-relational structures (e.g., anatomical relationships, geological processes, etc.). An effective way to extract information from diagrams is to compare them [1]. Despite the utility of comparison, there is relatively little research on how best to place compared visuals in space to facilitate structural alignment (i.e., left-to-right, top-to-bottom, etc.). An exception to this is the *spatial alignment hypothesis* [2], which asserts that the underlying relational structure is most obvious when the *visuals are placed perpendicular to their structural axes,* such that the corresponding parts of each visual are in *direct* – as opposed to *impeded* – spatial alignment (see Fig. 1). Thus, the efficiency of visual comparison is an interaction between a) the placement of the visuals and b) the direction along which information changes (i.e., their structural axes). However, still unknown is whether this principle applies broadly to visuals with different axes, or whether the spatial alignment principle applies only to visuals with horizontal and vertical structures.

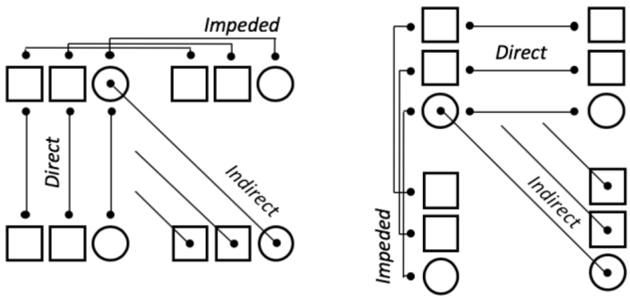

Fig. 1. Visual comparisons in direct, indirect, and impeded placements for visuals with horizontal (left) and vertical (right) structural axes.

2 Method

Participants were 22 adults. The trial and triplet dimensions and were identical to Experiment 1 in Matlen et al (2020) [2]. On each trial, a pair of triplets was presented, and subjects were asked to make a *same/different* judgment. The pairs varied across trials in a) the structural axes of the triplets (up-slanting or down-slanting, from left to right)—i.e., *Triplet*; b) pair placement—i.e., *Placement*; and c) whether the triplets were the same (1/3 of trials) or different (2/3 of trials)—i.e., *Concordance*. Conditions were within-subjects and all 432 trials were randomly presented. Varying the placement and triplet axes created four spatial alignment conditions: *Direct, Impeded, Indirect-H,* and *Indirect-V* (see Fig. 2). Based on spatial alignment, we predicted performance on direct trials to be faster and more accurate than on impeded trials, and possibly even than on indirect trials.

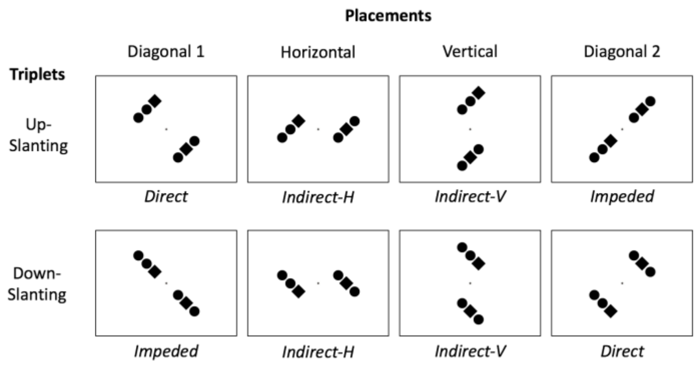

Fig. 2. Example stimuli used in the present Experiment. Stimuli varied in triplet direction (up- or down-slanting) and placement (diagonal 1, horizontal, vertical, or diagonal 2). The combination of triplet and placement created four spatial alignment conditions (denoted in italics).

3 Results

Trials recorded at 0ms were eliminated (<1% of trials). Error rates and response times for correct trials on each triplet and placement condition were averaged within participants. A 4 (placement) x 2 (triplet) within-subjects ANOVA revealed significant interactions within both response times $F(3,63) = 46.20$, $p < .001$, cohen's $f = 1.48$ and error rates $F(3,63) = 11.20$, $p < .001$, cohen's $f = .73$ (see Fig. 3). Regardless of triplet condition, participants were faster and more accurate on Direct and Indirect-H trials vs. Impeded trials (ps<.05).

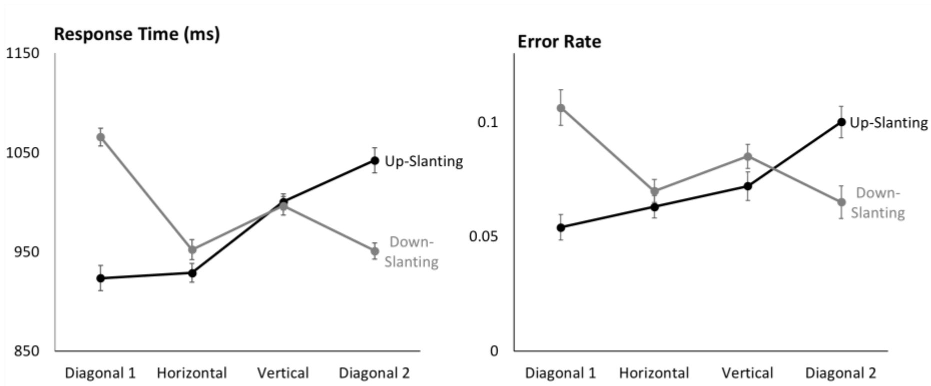

Fig. 3. Avg response times (left) and error rates (right). For up-slanting triplets, diagonal 1 placements are direct and diagonal 2 placements are impeded. Vice versa for down-slanting triplets.

4 Discussion

Results presented here support the spatial alignment hypothesis: Participants were faster and more accurate on direct relative to impeded trials. However, an unpredicted result concerns participants faster performance on horizontally placed pairs vs. vertically placed pairs. In fact, there was no significant advantage of direct placement over indirect *horizontal* placement. We suggest that this advantage may be the result of extensive practice in encoding horizontal sequences (e.g., reading direction). These results are broadly applicable to any visual comparisons involving diagonal structures (e.g., cladograms, steps in a process).

References

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